RINSE NOZZLE AND METHOD

FIELD OF THE INVENTION

[0001] The invention relates to the field of semiconductor device manufacturing, and, more particularly, to rinsing and drying of a substrate on a semiconductor wafer, including, but not limited to, a silicon wafer and an insulating circuit board, on which semiconductor devices are fabricated by semiconductor device manufacturing processes.

BACKGROUND

[0002] Semiconductor device manufacturing pertains to process steps of fabricating integrated circuits in successive layers of a substrate that is built on a semiconductor wafer. Some of the process steps leave residues to be removed by rinsing and drying of the semiconductor wafer.

[0003] Prior to the invention, the substrate was dried solely by spinning the semiconductor wafer while it was being held by a wafer holder on a robot arm. Incomplete drying would leave residues of DI water on the substrate, which would encourage chemical ionization and other chemical reactions that decrease the yield of integrated circuits that are fabricated on the substrate. However, an attempt to achieve complete drying of the substrate, by prolonging the drying cycle period, would cause unacceptable declines in productivity and throughput of wafer batches. An attempt to achieve complete drying of the substrate, by a high spin-dry speed, by spinning the wafers faster, would increase the momentum of the rinsing fluid mass, to splash and rewet the substrate. Thus, a need exists for a process and apparatus for completely drying the substrates within a reasonable drying cycle period.

SUMMARY OF THE INVENTION

[0004] According to the invention, a substrate is completely dried within a reasonable drying cycle period. An embodiment of the invention is a process for rinsing and drying a substrate on a semiconductor wafer, by dispensing rinsing fluid on the substrate during a rinsing cycle; and spinning the wafer about an axis of rotation during a drying cycle to dry the wafer, while dispensing dry gas under pressure against the substrate to dry the wafer completely.

[0005] Another embodiment of the invention is apparatus having, a first nozzle dispensing rinsing fluid against the substrate during a rinsing cycle, and a second nozzle dispensing dry gas under pressure against the substrate during a drying cycle to dry the substrate completely.

[0006] Although the invention will be described by referring to photolithography, the invention applies to any of the different integrated circuit manufacturing processes that leaves residues to be removed by rinsing and drying of a semiconductor wafer.

[0007] An embodiment of the invention will now be described by way of example with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1A is a diagrammatic view of an apparatus for rinsing and drying a substrate on a semiconductor wafer.

[0009] FIG. 1B is a view similar to Fig. 1, and discloses a drying process step.

[0010] FIG. 2 is a circuit diagram of a circuit that controls an apparatus for rinsing and drying a substrate on a semiconductor wafer.

DETAILED DESCRIPTION

[0011] This description of the exemplary embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. In the description, relative terms such as "lower," "upper," "horizontal," "vertical," "above," "below," "up," "down," "top" and "bottom" as well as derivative thereof (e.g., "horizontally," "downwardly," "upwardly," etc.) should be construed to refer to the orientation as then described or as shown in the drawing under discussion. These relative terms are for convenience of description and do not require that the apparatus be constructed or operated in a particular orientation. Terms concerning attachments, coupling and the like, such as "connected" and "interconnected," refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise.

[0012] Fig. 1 discloses a substrate (100), including, but not limited to one or more layers of material. The substrate (100) is on a semiconductor wafers (102), including, but not limited to,

a silicon wafer and an insulating circuit board, on which semiconductor devices are fabricated by semiconductor device manufacturing processes. The invention relates to rinsing and drying of the substrate (100) on a semiconductor wafers (102). Although the invention will be described by referring to photolithography, the invention applies to any of the different integrated circuit manufacturing processes that leaves residues to be removed by rinsing and drying of a semiconductor wafers (102).

[0013] Photolithography involves manufacture of an integrated circuit pattern by, first, patterning a beam of light with a patterned mask, and focusing the patterned beam onto a light sensitive layer that serves as a photo resist, PR (104). The PR (104) covers an underlying layer of a substrate (100) on a semiconductor wafers (102). Exposure of the PR (104) to the patterned beam will photograph the pattern onto the PR (104). Then, the photographed, PR (104) is developed by treatment with a chemical developer to provide an open pattern through the PR (104).

[0014] Following photolithography, the patterned photo resist (104) is in place during etching, to etch an integrated circuit pattern in the underlying layer of the substrate (100).

[0015] The substrate (100) must be rinsed and dried, following development of the photo resist (104). Thus, the chemical developer is removed by rinsing the substrate (100) with a rinsing fluid, for example, de-ionized water, DI water. Then, the substrate (100) is dried to remove the rinsing fluid.

[0016] Fig. 1 further discloses a portion of a motor driven wafer holder (106). A commercially available, industry known wafer processing apparatus has such a wafer holder (106) on a motor driven robot arm (108). The wafer holder (106) and robot arm (108) are programmed by computer to automatically pick up individual wafers (102) from a batch of wafers (102) and guide the wafers (102) through a manufacturing equipment that performs a manufacturing operation on the wafers (102). When the manufacturing process cycle is complete, the robot arm (108) returns the individual wafers (102) to the batch.

[0017] For example, the wafer holder (106) and robot arm (108) guides the wafers (102) through rinsing equipment while a rinsing process step is performed on the wafers (102). For example, a first nozzle (110) on a motor driven, auxiliary robot arm (112) dispenses the rinsing fluid, DI water supplied through a motor controlled valve (110a) to the first nozzle (110). Following a rinsing cycle, the wafer holder (106) on the first robot arm (108) is equipped to spin

the wafers (102) edgewise as they are being held edgewise by the wafer holder (106). Prior to the invention, the substrate (100) was dried solely by spinning the semiconductor wafer (102) while it was being held by a wafer holder (106) on the first robot arm (108).

[0018] Almost all of the wafers (102) would have traces of rinsing fluid following a spin-dry cycle. The rinsing fluid, i.e., DI water, near the center of rotation of the wafer (102) could not be ejected easily, due to lack of sufficient linear velocity, and due DI water in vapor form lacking sufficient mass for ejection. The rinsing fluid on the substrate (100) would cause the photo resist (104) to peel from the substrate (100) at localized areas where the traces of rinsing fluid remained after a spin-drying cycle.

[0019] When DI vapor at HB will produce the stress between DI and PR it will induce peeling of the photo resist (104) from the substrate (100). Please explain HB. Please explain what is meant by this sentence at page 2 of the Power Point information.

[0020]

[0021] Traces of the rinsing fluid that would remain on the photo resist (104) would weaken the bond between the photo resist (104) and the substrate (100). The photo resist (104) would peel, due to the weakened bond. Peeling of the photo resist (104) would lower the manufacturing yield of integrated circuits being fabricated on the substrate (100).

[0022] The invention obtains complete drying of the substrate (100) without prolonging the spin-dry cycle and without increasing the spin speed generated by the wafer holder (106). With reference to Fig. 1, a second nozzle (114) is beside the first nozzle (110). During a rinse cycle, the first nozzle (110)is moved by the auxiliary robot arm (112) to point a discharge end of the first nozzle (110)at the substrate (100) near the axis of rotation. The location coordinates of the axis of rotation are known by moving the first nozzle (110) by the auxiliary robot arm (112). The rinse cycle is performed by dispensing rinsing fluid from the first nozzle (110) onto the substrate (100), while the wafer holder (106) spins the semiconductor wafer (102) about the axis of rotation. Following the rinse cycle, the flow of rinsing fluid is shut off from the first nozzle (110).

[0023] Fig. 1A discloses that the auxiliary robot arm (112) moves the first nozzle (110) away from the axis of rotation, and moves the second nozzle (114) to replace the first nozzle, which points a discharge end of the second nozzle (114) at the substrate (100) near the axis of rotation. The drying cycle is performed by the wafer holder (106) spinning the wafer (102) while

dry gas is dispensed under pressure to eject rinsing fluid near the axis of rotation. The gas is supplied through a motor controlled valve (114a) to the second nozzle (114) that dispenses the gas. The dry gas desiccates a vaporous film of rinsing fluid near the axis of rotation. Thus, the substrate (100) is dried by a combination of expelling and desiccation. For example, the dry gas is gaseous Nitrogen, N_2, under pressure.

[0024] Thus, a process for rinsing and drying a substrate (100) on a semiconductor wafer (102) involves, dispensing rinsing fluid on the substrate (100) during a rinsing cycle; and spinning the wafer (102) about an axis of rotation during a drying cycle to dry the wafer (102), while dispensing dry gas under pressure against the substrate (100) to dry the wafer (102) completely.

[0025] When the drying cycle is finished, the auxiliary robot arm (112) is moved away, and the robot arm (108) returns the wafer (102) to the wafer batch where it is released by the wafer holder (106).

[0026] Fig. 2 discloses a control circuit (200) having a microprocessor (202) with an input clock signal CK 1 and an interconnection V1 with a computer or with a server for connection to a network. The microprocessor (202) is programmed by a computer to send the following control signals. First control signals are sent to a control circuit (204) of a motor drive of the first robot arm (108). Second control signals are sent to a control circuit (206) of a motor drive of the wafer holder (106). Third control signals are sent to a control circuit (108) of a motor drive of the auxiliary robot arm (112). Fourth control signals are sent to a control circuit (210) of the motor controlled first valve (110a) supplying rinsing fluid to the first nozzle (110). Fifth control signals are sent to a control circuit (212) of the motor controlled second valve (114a) supplying rinsing fluid to the second nozzle (114).

[0027] The microprocessor (202) signals the control circuit (210) to open and close the valve (110a) during a rinsing cycle. The microprocessor (202) signals the control circuit (206) to spin the wafer (102) during a drying cycle to dry the wafer (102), while signals to the control circuit (212) opens and closes the valve (114a) to dispense dry gas under pressure against the substrate (100) to dry the wafer (102) completely.

[0028] The microprocessor (202) signals the control circuit (208) for moving a first nozzle (110) to point to the substrate (100) near the axis of rotation (116), while the microprocessor (202) signals the control circuit (210) to open and close the valve (110a) for

dispensing the rinsing fluid through the valve (110) during a rinsing cycle. The microprocessor (202) signals the control circuit (208) to move the second nozzle (114) to point to the substrate (100) near the axis of rotation (116), while the microprocessor (202) signals the control circuit (212) to open and close the valve (114a) for dispensing the gas though the nozzle (114) during a drying cycle.

[0029] Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claims should be construed broadly, to include other variants and embodiments of the invention, which may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.